Physics 22 Practice Midterm - 50 minutes

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Thursday, April 28

Write your answers in a blue book. Calculators and two page of notes allowed. No textbooks allowed. Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**

Remember the real midterm will take place on Monday, May 2.

Take the acceleration of gravity near the earth's surface as $g = 10 \, \text{m/s}^2$ and the speed of light to be $c = 3 \times 10^8 \, \text{m/s}$ = $0.3 \, \text{m/ns}$ = $30 \, \text{cm/ns}$. Here 'ns' means a 'nano-second' which is $1 \times 10^{-9} \, \text{s}$. Take the density of water to be $\rho = 1000 \, \text{kg/m}^3$.

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1. In this problem S refers to an inertial system x, y, z, t and S' refers to an inertial system x', y', z', t', moving along the x axis with velocity v relative to S. Call the ratio of v to the speed of light $v/c = \beta$. The origins coincide at $t = t' = 0$.

    (a) Assume that an event occurs at coordinates $x = 30 \, \text{cm}$ and $t = 1/2 \, \text{ns}$ in S, and $\beta = \sqrt{3}/2$. What are the coordinates of the event, x' and t', in frame S'?

    (b) Is there a different frame S' moving at a different velocity β with respect to S where the event occurs at $t' = 0$, and if so, what is the coordinate x' of the event?

2. Imagine working with the densest material on earth, which is Osmium, $\rho = 22600 \, \text{kg/m}^3$.

    (a) What would a cube of dimension $L = 0.1 \, \text{m}$ weigh, in Newtons, if completely immersed in water?

    (b) You design a box of six square osmium plates, with sides $L = 0.1 \, \text{m}$. You want the assembled box to float in water. What is the maximum thickness of the plates?

3. You want to design a wing to lift a person of mass $m = 50 \, \text{kg}$ in air, which has density of $\rho = 1.23 \, \text{kg/m}^3$. The bottom of the wing is flat, and wind of speed $v_1 = 5 \, \text{m/s}$ goes straight along the bottom. However, the top of the wing is curved, and air that separates and goes along the top of the wing goes 10% faster than the air that goes straight along the bottom. What area, in square meters, must the wing have?